

Date: 25 May 2005

Analysis Request Statement:

Technical analysis Request 3.6: Assessment of the Potential Benefits and Costs of Long-term Captive populations on the Mainland and/or Islands.

Sub-Analysis 3.6.1:

Identify and describe the potential benefits, costs, and major issues associated with the following strategies (or combinations of thereof) for maintaining captive populations of island foxes:

- a. using existing on-island facilities
- b. expanding on-island facilities
- c. using existing space in mainland facilities (e.g., zoos)
- d. constructing new mainland facilities for island foxes

Sub-Analysis 3.6.2:

Identify to the extent possible the necessary steps and their logical progression for establishing and managing captive populations on the mainland

Sub Analysis 3.6.3:

If the establishment of mainland populations is determined to be both desirable and practical, identify weight criteria to be used to prioritize subspecies of the island foxes for representation in mainland populations.

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Chair of Expertise Group Assigned to Task Force: Peter Siminski, The Living Desert; Chair Captive Populations Expertise Group

Task Force Members: Karen Bauman, Saint Louis Zoo, Captive Populations Expertise Group; Peter Siminski, The Living Desert, Captive Populations Expertise Group; Alan Varsik, Santa Barbara Zoological Gardens, Captive Populations Expertise Group; Tim Coonan, National Park Service, Wild Populations Expertise Group; Colleen Lynch, AZA Population Management Center, Genetics Expertise Group ; Deanna Fritcher, Wildlife Health Center, Health Expertise Group; Gary Roemer; New Mexico State Univ., Wild Populations Expertise Group; Jonna Mazet, Univ. of California at Davis , Health Expertise Group; Linda Munson, Univ. of California at Davis, Health Expertise Group; Kathy Ralls, Population Modeling Expertise Group

Executive Summary:

It was quickly determined, due to the scope, significance and timeline of the Recovery Coordination Group (RCG) request, that the task force may function best by dividing into subgroups. Three subgroups were formed based on the three components of the request.

The analysis of 3.6.1 involved the creation of an array of matrices for the various alternatives requested versus disease risk, financial needs, genetic management, demographics and logistics. Managing foxes in existing captive situations presented the greatest costs associated with disease risk, while the greatest number of benefits associated with disease appears to be with the construction of new mainland facilities. The financial cost of managing foxes on the mainland appears to be less per fox compared to management on the islands. It is important to keep in mind that Alternative C, using existing space in mainland facilities, may require the least amount of outside or new resources as existing facilities absorb housing, husbandry, veterinary and food costs. Within the two mainland options, the cost per fox appears to be less when constructing new facilities on the mainland. Overall costs appear to increase as the number of foxes managed increases. From a genetic perspective, increasing the potential population size (population sizes increase with each alternative A-D) increases gene diversity retention and minimizes inbreeding, thus the potential larger mainland populations appear to be most beneficial. The same appears to be true for demography. The increased populations of the mainland facilities decrease the extinction risk and increase the availability of release specimens over the long term. Logistically, of course, the simplest alternative is just to continue using existing island facilities. The most complex may be using the existing mainland facilities, Alternative C, due to the number of institutions and personnel involved.

The analysis of 3.6.2 involved the creation of tables and outlines to identify the necessary steps and their logical progression for establishing and managing captive populations on the mainland. Six critical areas were identified for long-term maintenance of mainland populations including generating permits and protocols, developing AZA programs, implementing quarantine procedures between the mainland and the islands, preventative medicine while on the mainland, research to better facilitate population management, and financial oversight and development.

Without specific long-term goals, prioritizing subspecies for the establishment of a mainland population, request 3.6.3, is difficult. To best fulfill the request, criteria were identified including Genetics, Demography, Wild Population Status, Disease, and Immediate Rescue Need for Wild Population and a rating system, from Very Low to Very High, was applied. The key to choosing a subspecies for mainland management lies in first determining mainland management goals. Based on the goals identified by the group and the ratings given, it appears there is no outstanding subspecies that has a majority of recommendations for each category, but given a specified goal an appropriate population can be chosen.”

The overall analysis request was very dynamic in nature and proved to be quite challenging for the task force. In some cases specific recommendations could not be identified, but specific considerations and trade-offs were. Generally it appears that the creation of new mainland facilities would have the most significant benefit to the long-term conservation of the island fox. The necessary steps and logical progression towards establishing a mainland population has been identified based on other existing similar recovery efforts. Identifying which subspecies is the highest priority for creating a mainland population would likely be based on the goal or need of the program.

Sub-Analysis 3.6.1

Identify and describe the potential benefits, costs, and major issues associated with the following strategies (or combinations thereof) for maintaining captive populations of island foxes:

- a. using existing on-island facilities
- b. expanding on-island facilities
- c. using existing space in mainland facilities (e.g., zoos)
- d. constructing new mainland facilities for island foxes

Task Force Members - subgroup 3.6.2: Tim Coonan, National Park Service, Wild Populations Expertise Group (Chair subgroup); Karen Bateman, Saint Louis Zoo, Captive Populations Expertise Group; Jonna Mazet, Univ. of California at Davis, Health Expertise Group; Colleen Lynch, AZA Population Management Center, Genetics Expertise Group ; Deanna Fritcher, Wildlife Health Center, Health Expertise Group

Description of Alternatives

Alternative A Use Existing On-island Facilities

Under this alternative, island captive breeding facilities would not be expanded, and no portion of any island fox captive breeding program would move to mainland facilities. Breeding facilities on San Miguel, Santa Rosa, and Santa Cruz Islands would be managed at their current levels, which are 40 breeding animals (20 pairs) on each of the islands. There are two captive breeding facilities (of approximately 10 breeding pens each) on each of the three islands.

Alternative B Expand On-island Facilities

Under this alternative, each island facility would be expanded by 10 breeding pens, and each captive population would be managed at a higher captive level (30 pairs, or 60 breeding animals).

Alternative C Use Existing Space in Mainland Facilities

Under this alternative, existing space in mainland institutions would be utilized to house island foxes from one or more of the northern Channel Islands. There are currently xx spaces available in yy institutions. Thus, one of the subspecies would be managed at a level (zz breeding pairs) that included the current capacity of 20 pairs on the island, plus aa additional pairs in mainland institutions. Under this alternative, island foxes would likely be dispersed among many mainland institutions

Alternative D Construct New Mainland Facilities

Under this alternative, foxes from one or more subspecies would be housed in existing available space at mainland institutions, and in newly constructed small canid space in mainland institutions. Thus, one of the subspecies would be managed at a level (zz breeding pairs) that included the current capacity of 20 pairs on the island, plus aa additional pairs in mainland institutions. Under this alternative, island foxes would likely be clustered at 1-2 mainland institutions.

Summary of Effects

Table 1. Summary of costs and benefits associated with island versus mainland alternatives for island fox captive breeding.

Issue Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Disease Risk	Cost: 1) aging facilities and husbandry needs result in high maintenance costs; 2) moderate threat of disease being amplified in captivity and introduced into wild pop ⁿ ; 3) no room to rescue wild animals should catastrophic event occur on island.	Cost: 1) infrastructure, monitoring and veterinary capacity would need to be increased; 2) moderate threat of disease being amplified in captivity and introduced into wild pop ⁿ ; 3) conservation costs lower than eagle mortality unless catastrophic event impacts Island CBF; 4) may reduce wild habitat.	Cost: 1) moderate risk of mortality from treatment, quarantine and transport; 2) moderately increased risk of introduction of pathogens; 3) possibility that individual foxes will not return; 4) lack of mate choice or need to move between zoos; 5) use of existing facilities may not meet health and reproductive needs of foxes; 6) more likely stress of public exposure; 7) reduced exposure to natural diet & island pathogens.	Cost: 1) moderate risk of mortality from treatment, quarantine and transport; 2) moderately increased risk of introduction of pathogens (reduced relative to Alt. C); 3) possibility that individual foxes will not return; 4) reduced exposure to natural diet & island pathogens.
	Benefit: 1) genetic reserve; 2) reduced risk of new pathogens being introduced from the mainland; 2) reduced stress due to lack of long-distance transport and quarantine.	Benefit: 1) reserve pop ⁿ should disease epidemic occur in older pens or wild; 2) could improve husbandry, maximize reproduction, reduce injuries and facilitate research; 3) lack of stress of movement; 4) no increased risk of introduced diseases.	Benefit: 1) more experienced husbandry likely & access to veterinary care; 2) may improve reproduction & reduce overcrowding disease risk; 3) genetic reserve & increased variation.	Benefit: 1) reduce overcrowding; 2) possibly move from island to isolated enclosure w/o quarantine; 3) isolated from other carnivores; 4) no risk of infection from contaminated facility; 5) more experienced husbandry likely & access to veterinary care; 6) may improve reproduction & reduce overcrowding disease risk; 7) genetic reserve & increased variation; 8) large facility designed specifically for foxes will facilitate environmental enrichment, appropriate health care, maximize reproductive options, & facilitate necessary research & predator avoidance training.
Financial	Benefits: Landowner commitment stays at the	Benefits: -No additional costs of transport to	Benefits: -Island programs remain at sustainable levels	Benefits: -Island programs remain at sustainable levels

Issue Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
current, sustainable, level	mainland, quarantine and vet care, mainland husbandry and construction	-No new construction costs for mainland facilities	-No new construction costs for mainland facilities	No funding source as yet identified for the additional costs of transport to mainland, quarantine and vet care, and mainland husbandry, and exhibit/pen construction
-No additional costs of transport to mainland, quarantine and vet care, mainland husbandry and construction	Costs: One-time cost to landowners of \$165,000 for pen construction -Annual costs of >\$1,021,000	Costs: No funding source as yet identified for the additional costs of transport to mainland, quarantine, sterilization of existing facilities, and vet care, and mainland husbandry	Costs: Additional costs of transport to mainland, quarantine, sterilization of existing facilities, and vet care, and mainland husbandry	Costs: Estimated costs: \$1,583,880 not including pen construction or land acquisition costs
Costs: Annual costs to landowners of \$634,000 Budget for vet care and maintenance/updating of on site facilities should likely be increased	Increased costs for vet care on site & to update existing facilities -Increasing the federal funding to this level is unlikely	Benefits: Minimal genetic benefit.	Benefits: Increased population size increases gene diversity retention and minimizes inbreeding.	Benefits: Increased population size increases gene diversity retention and minimizes inbreeding.
Genetic Mgt.	Benefits: No genetic benefit.	Costs: Small population size limits gene diversity retention and increases inbreeding.	Costs: No genetic cost.	Costs: No genetic cost.
Demographic	Benefits: No demographic benefit.	Costs: Proposed island facility expansions are not sufficient to alleviate extinction risk under current harvest demands. Small population size increases extinction risk. Single facility increases extinction risk due to catastrophe.	Benefits: Minimal demographic benefit.	Benefits: Increased population size decreases extinction risk and increases availability of release specimens over long term.
				Costs: Decreased availability of release specimens during population growth phase.

Issue Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Logistics	<p>Benefits: No impacts to island operations or infrastructure, and no additional problems of transporting animals to mainland or among mainland facilities. No need for additional quarantine facilities or soft-release methods.</p> <p>Costs: Access to vet care and facilities is less than under C or D but could be kept to a minimum with pen improvements (feeding shelves, observable den spaces) and increased camera use.</p>	<p>Benefits: No additional problems of transporting animals to mainland or among mainland facilities. No need for additional quarantine facilities or soft-release methods.</p> <p>Costs: Expanded captive breeding facility and operation greatly impacts island operations and infrastructure.</p> <p>Captive breeding dominates NPS activity on Miguel and Rosa. Additional buildings and vehicles required. As under Alt. A, access to vet care and facilities is less than under C or D but could be kept to a minimum with pen improvements (feeding shelves, observable den spaces) and increased camera use.</p>	<p>Benefits: Island operations are relatively unaffected. Foxes housed on the mainland would have better access to vet care, and better opportunities for monitoring.</p> <p>Costs: Additional on-island quarantine facility required for foxes traveling to/from the mainland. Soft-release methods would likely be necessary for reintroduction to island environments. There would be additional logistical challenges in transporting foxes to, from and among mainland facilities.</p>	<p>Benefits: Same as under Alt. C, with additional benefits accrued from housing all foxes at 1-2 institutions (such as consistent vet care, standardized monitoring, less animal transport issues).</p> <p>Costs: Additional on-island quarantine facility required for foxes traveling to/from the mainland. Soft-release methods would likely be necessary for reintroduction to island environments. There would be additional logistical challenges in transporting foxes to, from and among mainland facilities.</p>

Risk of Disease

Table 2. Costs and benefits of different captive breeding alternatives regarding risk of disease.

Disease Risk To:	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Foxes remaining in on-island CBF	<p>Cost: 1) aging facilities and husbandry needs result in high maintenance costs and moderate threat of disease being amplified in captivity and increased mortality or impaired reproduction;</p> <p>2) conservation costs lower than eagle mortality unless catastrophic event impacts island CBF.</p> <p>Benefit: 1) existing genetic reserve to prevent extinction if catastrophic event in the wild; 2) lack of stress of movement to mainland and no change in risk of introduced diseases.</p>	<p>Cost: 1) temporary disturbance may alter behavior and impair reproduction if construction is close to existing pens; 2) infrastructure and fox health monitoring and veterinary medical capacity would need to be increased to address larger number of captive foxes; 3) moderate threat of disease being amplified in captivity and increased mortality or impaired reproduction;</p> <p>Benefit: 1) may help relieve overcrowded conditions, thereby reducing disease risk; 2) additional genetic reserve to avert extinction.</p>	<p>Cost: 1) moderately increased risk of introduction of mainland disease into captive island popⁿ</p> <p>Benefit: 1) will help relieve overcrowded conditions, thereby reducing disease risk; 2) removal of offspring from island CBF may increase repro in parents.</p>	<p>Cost: 1) reduced risk (relative to Alt. C) of introduction of a mainland pathogen into wild popⁿ</p> <p>Benefit: 1) will help relieve overcrowded conditions, thereby reducing disease risk; 2) removal of offspring from island CBF may increase repro in parents.</p>

Disease Risk To:	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Foxes moving to mainland CBF	NA	NA	<p>Cost: 1) moderate risk of morbidity or mortality due to medical treatment or stress in quarantine and transport; 2) moderately increased risk of exposure to mainland pathogens; 3) possibility that individual fox will not be able to return to island due to infection with a mainland pathogen or other medical problem; 4) lack of mate choice or need to move between zoos to find mates, thereby increasing chances for disease exposure; 5) use of existing facilities may not meet health and reproductive needs of foxes; 6) more likely to be on exhibit (relative to Alt D) with stress of public exposure; 7) reduced opportunity for exposure to natural diet.</p> <p>Benefit: 1) may be able to move from island to new isolated enclosure without separate and lengthy quarantine; 2) can be isolated from other carnivores; 3) no risk of infection from housing in preexisting contaminated facility; 4) likely to have more experienced husbandry and access to veterinary care; 5) large facility designed specifically for foxes will facilitate environmental enrichment, appropriate health care, maximize reproductive options, and additional genetic reserve to diseases.</p>	<p>Cost: 1) moderate risk of morbidity or mortality due to medical treatment or stress in quarantine and transport; 2) moderately increased risk of exposure to mainland pathogens (reduced relative to Alt C); 3) possibility that individual fox will not be able to return to island; 4) reduced opportunity for exposure to natural diet.</p> <p>Benefit: 1) may be able to move from island to new isolated enclosure without separate and lengthy quarantine; 2) can be isolated from other carnivores; 3) no risk of infection from housing in preexisting contaminated facility; 4) likely to have more experienced husbandry and access to veterinary care; 5) large facility designed specifically for foxes will facilitate environmental enrichment, appropriate health care, maximize reproductive options, and additional genetic reserve to diseases.</p>

Disease Risk To:	Alternative A Use Existing On-Island Facilities	Alternative B Expand On-Island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Foxes returning to island (during transport)	NA	NA	<p>Cost: 1) moderate risk of morbidity or mortality due to medical treatment or stress in quarantine; 2) possibility that individual fox will not be able to return to island due to infection or other medical problem detected during on island quarantine; 3) increased vulnerability to infection with island pathogens (<i>Spirocerca</i>, <i>Angiocaulus</i>) may result in morbidity/mortality.</p> <p>Benefit: Opportunity to add genetic variation to existing population.</p>	<p>Cost: 1) moderate risk of morbidity or mortality due to medical treatment or stress in quarantine; 2) possibility that individual fox will not be able to return to island due to infection or other medical problem detected during on island quarantine; 3) increased vulnerability to infection with island pathogens (<i>Spirocerca</i>, <i>Angiocaulus</i>) may result in morbidity/mortality.</p> <p>Benefit: Opportunity to add genetic variation to existing population.</p>
Foxes returning to island wild pop ⁿ	NA	NA	<p>Cost: 1) lack of acclimation/loss of natural behaviors may increase predation risk and impair repro and foraging success in wild; 2) increased vulnerability to infection with island pathogens (<i>Spirocerca</i>, <i>Angiocaulus</i>) may result in morbidity/mortality.</p>	<p>Cost: 1) lack of acclimation/loss of natural behaviors may increase predation risk and impair repro and foraging success in wild (less likely than Alt. C if facility is mitigating this risk); 2) increased vulnerability to infection with island pathogens (<i>Spirocerca</i>, <i>Angiocaulus</i>) may result in morbidity/mortality.</p>

Disease Risk To:	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Wild popⁿ	<p>Cost: 1) aging facilities and husbandry needs result in high maintenance costs and low-moderate threat of disease being amplified in captivity and introduced into wild popⁿ; 2) no room to rescue wild animals should catastrophic event occur on island.</p> <p>Benefit: 1) reduced risk of new pathogens being introduced from the mainland; 2) reduced stress due to lack of long-distance transport and quarantine.</p>	<p>Cost: 1) CBF expansion may encroach into wild fox territory and cause increased interactions (that may cause injury or disease spread) between wild and captive foxes – preventable with properly designed perimeter fencing; 2) may increase threat of disease being amplified in captivity and introduced into wild popⁿ if design of and husbandry in new facilities will be substantially limited by funding availability.</p> <p>Benefit: Opportunity to add genetic variation to existing population.</p>	<p>Cost: 1) moderately increased risk of introduction of a mainland pathogen into wild popⁿ.</p> <p>Benefit: 1) possibly increased repro in wild as foxes have more mate choices with reintroduced foxes.</p>	<p>Cost: Incorporated in benefit below.</p> <p>Benefit: 1) reduced risk (relative to Alt. C) of introduction of a mainland pathogen into wild popⁿ due to proper facility construction and control over number of locations of mainland CBF</p>

Financial Costs

Table 3. Financial costs of different captive breeding alternatives.

Financial Sub-Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Pen Construction	40 adults/subspecies	60 adults/subspecies	100 adults/subspecies	150 adults/subspecies
Replace aging pens (annually) 3 islands @ 12K – 20K (first year) = 36,000 – 60,000	Construct new pens to house 60 foxes/island 165,000 + replace aging pens 36,000	Already existing on mainland, but remaining island captive subpopulations will require replacement of aging pens (annually) 2 islands @ 12K = 24,000	Already existing on mainland, but remaining island captive subpopulations will require replacement of aging pens (annually) 2 islands @ 12K = 24,000	Comparable facilities would likely be lower cost than island facility. If land is needed, costs could be significant. Still need to replace aging island pens (annually) 2 islands @ 12K = 24,000
Personnel	8 techs, 2 lead, 1 biologist	12 techs, 2 lead, 1 biologist	100 foxes(50 pairs)@ \$13.26/pair/day x 365 days = 241,995/ subspecies	150 foxes (75 pairs)@ \$13.26/pair/day x 365 days = \$362,993/subspecies x3= 1,088,977
Travel (island per diem)	24,000	36,000	24,000 if 2 subspecies remain on island	24,000 if 2 subspecies remain on island
Transportation (flights)	45,000	60,000	30,000 if 2 subspecies remain on island	30,000 if 2 subspecies remain on island
Fox Food	32,000	48,000	100 foxes @0.73/fox/day = 26,645/subspecies x3 = 79,935	150 foxes @0.73/fox/day = 39,968/subspecies x3 = 119,903
Veterinary Care	Half-time vet + sample testing 50,000	Full-time vet + sample testing 100,000	Routine medical care 100 foxes @ \$220/yr = \$22,000 x3 = \$66,000	Routine medical care 150 foxes @ \$220/yr = \$33,000 x3 = \$99,000

Supplies	25,000	Half-time vet + sample testing still needed for 2 on-island CBFs 50,000	Half-time vet + sample testing still needed for 2 on-island CBFs 50,000
Additional island quarantine facility	40,000	17,000 per island x3 = \$51,000	17,000 per island x3 = \$51,000
Transport of foxes to and from mainland		-- 100 foxes @ \$500/move = \$50,000/subspecies x3 = \$150,000	-- 150 foxes @ \$500/move = \$75,000/subspecies x3 = \$225,000
Total Costs			
One-time	165,000		
Annual total	634,000	1,021,000	1,072,920
Annual cost/adult fox	5,283	5,672	3,576
			1,583,880
			3,520

Alternate C and D – estimate does not include the costs associated with maintaining island captive facilities
 Alternate D - estimate does not include the cost of pen construction and land acquisition

Genetic Management

For the purposes of genetic and demographic management, it is the capacity of facilities, not their location, which determines projection outcome. For the purposes of TAR 3.6, varying capacities of 44 - 150 were assigned to Alternatives A-D assuming that each progressive Alternative would provide additive capacity to the program.

Table 4. Projected outcome of different captive breeding alternatives in regard to genetic management of captive fox populations. Expected population gene diversity (GD) at 25 years from present under random breeding is reported. Under managed breeding programs it is expected that retained GD will be higher than that retained under random breeding, but order of relative GD retained is not expected to change for populations under equivalent management strategies.

Genetic Mgmt. Sub-Category	Alternative A Use Existing On- island Facilities Capacity = 44	Alternative B Expand On-island Facilities Capacity = 64	Alternative C Use Existing Mainland Space Capacity = 100	Alternative D Construct New Mainland Facilities Capacity = 150
Santa Cruz (95% current GD)	70 %	74 %	82 %	85 %
Santa Cruz + founders (95% current GD)	80 %	84 %	87 %	89 %
Santa Rosa (93% current GD)	69 %	72 %	80 %	83 %
San Miguel (90% current GD)	64 %	70 %	77 %	80 %

Gene diversity projections for captive populations of 3 subspecies of island fox were conducted on the Island Fox North American Regional Studbook (current to 10 Jan 2005) using SPARKS V. 1.5 and Population Management 2000 V. 1.202. The true studbook was analyzed using standard assumptions of unrelated or equally related founders (an examination of the overall distribution of microsatellite-derived pair wise relatedness values was applied to examine the assumption of equally related founders, 2004 Analysis and Population Management Plan).

Variation in genetic projections stems from island-specific differences in population structure. The number of founders recruited into the population and the relative representation of those founders within the descendant population are the primary parameters influencing inter-island differences.

The Santa Cruz Island captive population has the greatest total number of founders (recruited and potential), the greatest number of recruited founders (15), the highest current gene diversity, and the greatest potential for gene diversity retention in the absence of additional potential founders. It is the only sub-species under consideration for which additional potential founders may be available. It is assumed that six additional founders could be acquired in program years 5, 15, and 25.

The Santa Rosa Island population has the second greatest total number of founders and the second greatest number of recruited founders (12). The San Miguel population has a similar total number of founders, with fewer recruited founders (7). Most remaining potential founders are older animals and recruitment is considered to be unlikely.

Demographic Management

For the purposes of genetic and demographic management, it is the capacity of facilities, not their location, which determines projection outcome. For the purposes of TAR 3.6, varying capacities of 44 -150 were assigned to Alternatives A-D assuming that each progressive alternative would provide additive capacity to the program.

Table 5. Projected outcome of different captive breeding alternatives in regard to demographic management of captive foxes. ZooRisk 1.2.1 and Vortex 9.51 projections were run for 25 years. Vital rates used are “model captive canid” rates derived from a survey of canid studbooks. Harvests are strict (16 animals are released per year regardless of annual population size) or variable (only animals in excess of capacity are released). In the variable harvest strategies, the first year of harvest availability is presented first; the first year in which harvest availability is greater than or equal to the 25 year average is presented in parentheses.

Demography Sub-Category	Alternative A Use Existing On-island Facilities Capacity = 44	Alternative B Expand On- island Facilities Capacity = 64	Alternative C Use Existing Mainland Space Capacity = 100	Alternative D Construct New Mainland Facilities Capacity = 150
Santa Cruz				
Strict Harvest $P(E) w/H=16$	100	93	10	0
Variable Harvest $P(E)$ Release start year Release availability	0 1 (5) 13	0 4 (6) 18	0 5 (7) 23	0 8 (9) 33
Santa Rosa				
Strict Harvest $P(E) w/H=16$	100	83	7	0
Variable Harvest				

Demography Sub-Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
	Capacity = 44	Capacity = 64	Capacity = 100	Capacity = 150
P(E)	0	0	0	0
Release start year	1 (4) 12	4 (5) 16	4 (6) 22	6 (8) 33

San Miguel

Strict Harvest P(E) w/H=16	100	93	24	2
Variable Harvest				
P(E)	0	0	0	0
Release start year	2 (8) 8	5 (7) 11	7 (9) 16	9 (10) 23
Release availability				

Vortex 9.51 and ZooRisk1.21, two individually-based, stochastic risk assessment models were used to generate extinction risk and release availability for three populations of island fox. The vital rates applied to all three populations are the same. Current studbook demographic data are insufficient to generate island-specific life tables or even a generalized island fox life table. Therefore, model vital rates were generated through an examination of life tables of other captive canid species. The assumption is made that captive island foxes, with optimal husbandry, will exhibit vital rates similar to those of closely related species, providing coarse estimations of target population size necessary to meet program goals. However, many of the studbooks surveyed did not represent populations being managed for maximum production related to a recovery program. The resulting lambda may, therefore, be conservative. While this model life table may not exactly represent island fox demography, it does allow a comparison of the relative demographic performance of the three island fox populations under equivalent management strategies.

Variations in demographic projections stem from the current population age structure. The Santa Rosa population currently exhibits a columnar age structure which closely approximates a stable distribution. The Santa Cruz population exhibits a generally pyramidal distribution but has a severe “pinch” in the second and third age classes. The San Miguel population exhibits an hourglass distribution with a severe “pinch” in the middle age classes. Irregularities in the age distributions lead to inconsistencies in production within

generations and cyclical patterns repeating between generations. These patterns may be mitigated over time through careful management of the age distribution. The impact of differences in current age distribution will be most apparent in the short-term (~one generation length). Following correction of age distributions, populations should perform equivalently barring inherent island-specific variations in vital rates.

Note: All Variable Harvest strategies include a cessation of releases until the population is grown to facility capacity. Allowing growth phase completion greatly reduces extinction risk due to over-harvest and may ultimately provide a greater number of individuals for release. For example:

40 animals @ lambda 1.2

year	strategy A				strategy B			
	$N_{t=0}$	$N_{t=1}$	$N_{released}$		$N_{t=0}$	$N_{t=1}$	$N_{released}$	
1	40	48	8		40	48	0	
2	40	48	8		48	58	0	
3	40	48	8		58	70	0	
4	40	48	8		70	84	0	
5	40	48	8		84	100	0	
6	40	48	8		100	120	20	
7	40	48	8		100	120	20	
8	40	48	8		100	120	20	
9	40	48	8		100	120	20	
10	40	48	8		100	120	20	

strategy A 80
animals
released
in 10 years

strategy B 100
animals released
in 10 years

Logistics

Table 6. Costs and benefits of different captive breeding alternatives regarding logistics.

Logistics Sub-Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Use Existing Mainland Space	Alternative C Construct New Mainland Facilities	Alternative D Construct New Mainland Facilities
Island Operations	<p>Benefits: Overall island operations remain relatively unaffected.</p> <p>Costs: Vet visits should be increased to monthly, but can likely use existing flights at least partially because of non-emergency basis.</p>	<p>Benefits: Expansion of captive populations from 40 to 60 foxes on each island (+ annual pups) would make captive breeding the dominant activity on the islands.</p> <p>Addition of another breeding facility on each island would expand the island area which is off-limits to non-fox staff and visitors. Weekly air transportation to San Miguel would be dominated by fox staff, and additional flights would be needed monthly for vet visits (plus medical necessity visits - which should be fewer than currently if facilities are better). On Miguel and Rosa, available bunks and use of NPS vehicles would be dominated by the</p>	<p>Benefits: Same as under Alt. A.</p> <p>Costs: None</p>	<p>Benefits: Same as under Alt. A.</p> <p>Costs: None</p>	<p>Benefits: Same as under Alt. A.</p> <p>Costs: None</p>

Logistics Sub-Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Island Infrastructure	Benefits: Effects on island infrastructure remain at current levels. Costs: None beyond the infrastructure needs of the current captive breeding operation.	Benefits: Additional bunks would need to be made available for additional staff and vet, to avoid impacting other island operations. Costs: None	Benefits: Same as under Alt. A., except for below. Costs: An additional quarantine facility would be required for foxes traveling to and from the islands.	Benefits: Same as under Alt. A., except for below. Costs: An additional quarantine facility would be required for foxes traveling to and from the islands.
Transport of Foxes	Benefits: No additional transportation needs for foxes traveling to and from the islands. Costs: None	Benefits: Same as under Alt. A. Costs: None	Benefits: None Costs: Additional costs of transporting foxes to/and from the islands and mainland, and among mainland institutions.	Benefits: The costs of transporting foxes among mainland institutions would be less than under Alt. C, if most foxes from one subspecies are clustered in 1-2 facilities. Costs: Additional costs of transporting foxes to/and from the islands and mainland, and among mainland institutions.
Access to Veterinary Care and Facilities	Benefits: Foxes housed on-island are cared for by at most 1-3 vets, insuring some consistency of care provided. Costs: Foxes housed on the islands have less	Benefits: Same as under Alt. A, with greater consistency of vet care resulting from hiring a full-time project vet. Costs: Same as under Alt. A.	Benefits: Foxes housed on the mainland would have immediate access to veterinary care and facilities. Costs: Foxes housed on the island would still have inadequate access	Benefits: Same as under Alt. C, with the possible additional benefit of increased consistency of veterinary care, if all foxes are housed at 1-2 mainland institutions.

Logistics Sub-Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Monitoring of Captive Foxes	<p>than ideal access to veterinary care. Because vets are not in residence on-island, there is a lag time in response to veterinary emergencies. Inadequate veterinary hospital care is available on the islands. Some foxes may suffer injury or illness or may die as a result of reduced access to veterinary care.</p> <p>Benefits: None</p> <p>Costs: Captive island foxes will not be adequately monitored. Opportunities for direct observation of foxes are limited, as is staff time available for observation. Monitoring can be increased significantly at minor cost via pen design changes (feeding shelves, observable den spaces), and some increased camera use.</p>	<p>Benefits: None</p> <p>Costs: Same as under Alt. A.</p>	<p>Benefits: There are greater opportunities for monitoring captive foxes than under A or B. Zoos have access to adequate power and personnel, unlike the island facilities.</p> <p>Costs: Monitoring may not be standardized, if foxes are dispersed among many facilities.</p>	<p>Benefits: Same as under Alt C, with the additional benefit of standardized monitoring, if all foxes of a certain subspecies are housed in 1-2 facilities.</p> <p>Costs: None</p>
	<p>vets are not in residence on-island, there is a lag time in response to veterinary emergencies. Inadequate veterinary hospital care is available on the islands. Some foxes may suffer injury or illness or may die as a result of reduced access to veterinary care.</p> <p>Benefits: None</p> <p>Costs: Captive island foxes will not be adequately monitored. Opportunities for direct observation of foxes are limited, as is staff time available for observation. Monitoring can be increased significantly at minor cost via pen design changes (feeding shelves, observable den spaces), and some increased camera use.</p>	<p>to veterinary care and facilities.</p> <p>Foxes housed at different mainland facilities may receive different veterinary care.</p>	<p>to veterinary care and facilities.</p> <p>Foxes housed at different mainland facilities may receive different veterinary care.</p>	<p>Benefits: Same as under Alt. C.</p>

Logistics Sub-Category	Alternative A Use Existing On-island Facilities	Alternative B Expand On-island Facilities	Alternative C Use Existing Mainland Space	Alternative D Construct New Mainland Facilities
Reintroduction of Foxes to the Wild	<p>the lack of power at breeding sites, and the marine environment make video camera monitoring difficult, though techniques to accomplish this have been proven on Catalina.</p> <p>No staff time available for video feed review.</p> <p>Some health issues will be missed because of inadequate monitoring.</p> <p>Benefits: No need for additional soft-release methods, since foxes are housed in pens within the environment in which they will be released.</p> <p>Costs: None</p>	<p>Benefits: Same as under Alt. A.</p> <p>Costs: Same as under Alt. A.</p>	<p>Benefits: None</p> <p>Costs: Because foxes are housed in mainland institutions and not in the environment in which they will be released, soft-release methods (temporary pens at the release sites) may be required for reintroduction.</p>	<p>Benefits: None</p> <p>Costs: Same as under Alt. C.</p>

Analysis Request Statement 3.6.2

Sub-group 3.6.2: Identify to the extent possible the necessary steps and their logical progression for establishing and managing captive populations on the mainland [e.g. identifying space, securing permits, addressing on-island and off-island quarantine issues, establishing an oversight strategy (e.g. Species Survival Plan), transporting animals, etc.]

Task Force Members - subgroup 3.6.2: Karen Bauman, Saint Louis Zoo, Captive Populations Expertise Group (Chair, sub-group); Jonna Mazet, Univ. of California at Davis, Health Expertise Group; Peter Siminski, The Living Desert, Captive Populations Expertise Group; Alan Varsik, Santa Barbara Zoo, Captive Populations Expertise Group

Introduction:

Sub group 3.6.2 had the task of identifying what steps would be involved in moving animals from the Channel Islands to mainland captive facilities. The decisions whether or not this move is merited and which animals would be moved are addressed separately.

We identified six critical areas for the establishment and long-term maintenance of a mainland captive population. These steps are:

1. ESA permits, authorizations and animal shipment protocols to establish mainland population
2. AZA Species Survival Plan (SSP) to provide oversight of mainland population
3. Quarantine between mainland and islands.
4. Preventive medicine while on mainland
5. Research into areas that limit the viability of a long-term captive population, e.g. lack of reproduction, disease, etc.
6. Financial oversight and development

The required tasks in each of these six steps, along with the responsible parties involved and a projected timeframe are listed in tabular format. Additional details relating to each area and task are also provided in outline format for further clarity.

Analysis: No quantitative analyses were used in addressing the question 3.6.2. Information was gathered from existing sources and from experiences with existing AZA captive breeding programs.

I. Table of critical steps with tasks, responsible parties and time frames

ESA permits, authorizations and animal shipment protocols to establish mainland population

Task	Timeframe	Responsible Parties
Establish an ESA permit held by FWS for all mainland activities, including holding, breeding, research and animal shipments	October 2005	FWS
Develop boiler-plate loan agreement from FWS to each mainland holding facility providing authorization and guidance on ESA activities	October 2005	SSP, FWS
Develop a standardized animal shipment protocol for off island transfers	October 2005	SSP
Develop mainland facility approval and review policies and procedures.	No later than June 2006	SSP, FWS

AZA Species Survival Plan (SSP) to provide oversight of mainland population

Task	Timeframe	Responsible Parties
Establish an MOU between AZA and USFWS	Completed	
Establish an AZA Island Fox SSP	Prior to June 21, 2005	AZA Canid TAG
Name a SSP Coordinator, Studbook Keeper and necessary Advisor(s)	Prior to June 21, 2005	AZA Canid TAG
Recognition by FWS of the AZA Island Fox SSP as the knowledgeable authority on mainland captive breeding for Island foxes	June 2005	FWS
Decide SSP goals for mainland population	October 2005	SSP, TAG, FWS, NPS
Recruit SSP institutions	On going	SSP
SSP Master Plan	October 2006	SSP

Quarantine between mainland and islands.

Task	Timeframe	Responsible Parties
Quarantine draft protocol written	Completed	
Quarantine draft submitted to Health TEG	Completed	
Finalize Quarantine protocol	Prior to June 15, 2005	Randy Junge for Health TEG
Present Quarantine protocol to Group	June 21, 2005	Health TEG

Preventive medicine while on mainland.

Task	Timeframe	Responsible Parties
Create standardized protocols for preventive medicine	October 2005	Health TEG

Research into areas that limit the viability of a long-term captive population

Task	Timeframe	Responsible Parties
Develop a three year research action plan	Summer 2005	Devra's Task Force
Design research studies identified in the research plan	Pending results of other task force	
Identify animals required for these research projects	As above	
Identify facilities required for these research projects	As above	

Financial oversight and development

Task	Timeframe	Responsible Parties
Set up FWS grant agreement with SSP	By June 2006	FWS
Each holding institution takes financial responsibility for animals held	On going	SSP, Each holding facility
Liaise with Friends of the Island Fox (FIFI) for development activities	On going	SSP, FIFI, FWS
ID private sources of funding	On going	SSP, FIFI

ID grant sources of funding	On going	SSP, FIFI
Set up gifted endowment	June 2006	FIFI

II. Outline of details of required steps to move animals to mainland captive facilities as outline in the table above.

- 1) ESA permits, authorizations and animal shipment protocols to establish mainland population
 - a) Establish an ESA permit to be held by FWS for all mainland activities. This includes: holding, breeding, research and animal shipments. All captive facilities would be sub-permittees as established in loan agreements with FWS (see 1b for loan agreement).
 - b) Develop a “boilerplate” loan agreement from FWS to each mainland holding facility providing authorization and guidance on ESA activities. This is an agreement between FWS (the ESA permit holder) and each facility. If a facility is approved by FWS, they will then issue this “boilerplate” loan agreement for island fox activities, thus the loanee will be working under the FWS’s permit. The loan agreement will spell out the responsibilities of the loanee, such as, complying with SSP breeding and transfer recommendations, following SSP husbandry guidelines, and notification of deaths. The loan agreement also memorializes FWS’s ultimate authority on all matters relating to island foxes.
 - c) Develop a standardized animal shipment protocol for off island transfers using the AZA Clemente Island PMP Husbandry Manual, IATA regulations, existing Island captive program (NPS, Conservancy, etc) protocols and other related sources. This protocol will be used for all off-island transfers. Copies of the protocol should be filed with FWS and incorporated into the Island Fox SSP Husbandry Manual for reference.
 - d) Develop mainland facility approval and review policies and procedures. Procedures would involve the SSP Coordinator selecting a qualified inspector for each candidate facility and supplying the inspector with a standardized facility inspection form. The inspector inspects the candidate facility and provides a written report and recommendation for the SSP Coordinator. The SSP Coordinator or a SSP management group can concur with the recommendation, require modifications of the candidate facility, or disagree with the recommendation. When the SSP Coordinator or management group approves a recommendation, the recommendation is passed on to FWS for their consideration. If FWS agrees with the recommendation, they issue a permit as described in 1b above.
- 2) AZA Species Survival Plan (SSP) to provide oversight of mainland population
 - a) Establish an MOU between AZA and USFWS – Completed; Copy attached as an appendix to this document.
 - b) Establish an Island Fox SSP with the primary purpose of managing the mainland population using the AZA’s successful procedures for *in situ / ex situ* conservation efforts in order to meet FWS recovery goals for island foxes. The SSP:

- i) Promotes the program within the AZA and recruits new facilities.
 - ii) Works with the AZA Population Management Center and all cooperating holding facilities to decide annual transfer and breeding recommendations for final approval by FWS. Planning is done in coordination with wild population and island captive population planning.
 - iii) Coordinates review of all candidate facilities
 - iv) Facilities provide funding to carry out normal holding, breeding and transfer activities for their own institution as part of SSP membership.
 - c) Name a SSP Coordinator who will coordinate the mainland population and be the primary FWS contact. This Coordinator will work with the AZA Canid TAG to select a Studbook Keeper and find the necessary SSP Advisor(s). Given the existing challenges in the areas of Veterinary Medicine, Genetics and Reproduction, it is strongly suggested that advisors from these disciplines be a part of the SSP from its formation. These advisors will facilitate communication between the SSP and the relevant FWS Island Fox Technical Expertise Groups (TEG), in addition to providing relevant information to the SSP holding institutions.
 - d) Recognition by FWS of SSP as the knowledgeable authority of mainland captive breeding for Island foxes. FWS is the ultimate authority on all matters relating to island foxes. However, the AZA's successful procedures for *in situ/ex situ* conservation efforts will be utilized by FWS in the form of the Island Fox SSP to manage the mainland captive population. Thus allowing FWS resources to be utilized in other areas of Island fox conservation.
 - e) The AZA Canid TAG works with FWS and the SSP to set goals for mainland population.
 - f) Recruit SSP institutions to hold individuals for the targeted population.
 - g) SSP Master Planning (genetics and demography) using the goals set in 2e above, the SSP will work with the Genetics Advisor and/or the AZA Population Management Center to provide advising in all matters of population biology including:
 - i) Long-term genetic and demographic management strategies,
 - ii) Annual population analysis
 - iii) Annual recommendations for breeding, transfer, and release
 - iv) Metapopulation management recommendations for integrated captive/wild management
- 3) Quarantine both ways between mainland and islands.
- a) Quarantine protocol written
 - i) Draft submitted to Health TEG and finalized
 - ii) Present Quarantine protocol to FWS for approval
 - b) Identify quarantine facilities as specified in quarantine protocol
 - i) The type and number of quarantine facilities will be highly dependent upon the type and number of mainland facilities involved. Some island fox have a spirocercid parasite which has not been identified in the mainland U.S., so we need to mitigate infection prior to transport to the mainland. Therefore, quarantine and treatment will need to begin on island and then continue on the

mainland. These quarantine issues would be facilitated by few institutions and larger collections. If new facilities are constructed, mainland quarantine could possibly take place in the newly constructed enclosure without the need for separate mainland quarantine facilities.

- 4) Health – Preventive medicine while on mainland
 - a) The SSP Veterinary Advisor will work with the Health TEG to create standardized protocols for preventive medicine, including vaccines and parasite control programs. Copies of these protocols should be filed with FWS and incorporated into the Island Fox SSP Husbandry Manual for reference.
- 5) Research into areas that limit the viability of a long-term captive population
 - a) Develop a three-year research action plan to investigate issues that limit the viability of a long-term captive population. These concerns are being addressed in a separate Task Force (led by Devra Kleiman). It is clear that current issues in the current island captive facilities, e.g. lack of reproduction in captive bred animals, could impact the success of a long term captive population and may threaten the long-term viability of species.
 - i) Design research studies identified in the research plan
 - ii) Identify animals required for these research projects
 - iii) Identify facilities required for these research projects
- 6) Financial oversight and development
 - a) Set up FWS grant agreement with SSP.
 - i) Establish a FWS Grant to the SSP Coordinator's institution under the Partnership for Wildlife Act. The purpose of this grant will be to provide financial support for the SSP Coordinator's institution to fund Island Fox SSP activities submitted by participating SSP facilities that are determined to be important for island fox recovery. This is a mechanism that provides more agile money handling to cover non-typical SSP participant expenses, such as, inspection visits to candidate facilities or expenses for non routine activities asked for by FWS. This is not a lot of money, maybe \$5,000 for three years. However, it gets the money more quickly to the participating facility and cuts down on FWS paper work and long processing times.
 - b) Each SSP holding institution takes financial responsibility for animals held
 - c) Protect long-term funding stability
 - i) ID private sources of funding
 - ii) Liaise with Friends of the Island Fox for fund raising possibilities
 - iii) ID grant sources of funding
 - iv) Set up gifted endowment

Appendix: Existing MOU between AZA and FWS

Sub-analysis 3.6.3

If the establishment of mainland populations is determined to be both desirable and practical, identify weighted criteria to be used to prioritize subspecies of island foxes for representation in mainland populations. Potential criteria to consider for each subspecies could include, but are not limited to, genetic attributes, status of wild and captive populations, current and potential risks to on-island wild and captive populations, and any special challenges (e.g., *Spirocerca* and *Angiocaulus* issues).

Task Force Members - subgroup 3.6.3: Colleen Lynch, AZA Population Management Center, Genetics Expertise Group (Chair sub-group); Kathy Ralls, Population Modeling Expertise Group; Tim Coonan, National Park Service, Wild Populations Expertise Group; Gary Roemer; New Mexico State Univ., Wild Populations Expertise Group

GENERAL METHODS

Criteria considered in the selection of an island subspecies for mainland management should include factors in the categories of Genetics, Demography, Wild Population Status, Disease, Immediate Rescue Need for Wild Population, and possibly others. Given a lack of clear program goals for mainland populations, however, it is difficult to determine how to score factors within categories and even more difficult to weigh categories against one another. In the absence of clear program goals for the mainland population the task force members decided not to weigh various criteria or assign numerical scores within criteria. The task force members felt that the final decision regarding the choice of a subspecies should be made by the RCG rather than by the task force.

Rather, the task force rated criteria under each of the categories used (genetics, demography, wild status, disease risk, and immediate rescue need) verbally from very low to very high (Table 1). A rating of VERY HIGH in Table 1 indicates that a subspecies is the best choice for a mainland population considering only that particular category, e.g. genetics. In some instances, e.g. demography, ratings were derived through the use of population modeling. In other cases ratings were assigned based on expert opinion, i.e. the collective knowledge of the task force members and other knowledgeable people that were consulted. A more detailed explanation of the meanings of the criteria in each category of Table 1 is provided below. Summary Results within categories are presented in Table 2. Again, categories are not weighted.

GENETICS

Population modeling of current Santa Cruz, Santa Rosa, and San Miguel captive populations was conducted to determine ratings. Ratings for Santa Catalina were deduced assuming collection of an ideal captive population. Detailed genetic model results are presented in TAR 3.6.1.

Gene Diversity at 25 years: A population with the greatest potential for maintaining genetic variation over time might be the most suitable population for mainland management and VERY HIGH indicates populations with the highest projected gene diversity (proportion of source population variation remaining in the descendant population) over time. Populations with the greatest number of recruited founders and potential for future founder acquisitions are likely to maintain higher levels of genetic variation over time, providing a genetically robust population to fulfill long-term program goals. In the short-term, little opportunity for drift and selection exists, but given a long-term (greater than 20 years) management goal, genetics are of generally high concern to managed programs. Santa Cruz is rated VERY HIGH due to large number of recruited founders and potential for additional founders.

Suitability for stocking other islands based on phylogeny: If an important goal of the mainland population is to serve as hedge against catastrophic extinction events on one or more of the Channel Islands, the phylogenetic history of these populations is an important consideration. Santa Cruz is rated HIGH on this criterion because it is the ancestral population (Gilbert et al. 1990, Goldstein et al. 1999).

Suitability for stocking other islands based on molecular measures of variation: If an important goal of the mainland population is to serve as hedge against catastrophic extinction events on one or more of the Channel Islands, current levels of genetic variation is another important consideration. Santa Rosa (57% H) rates HIGH having the highest level of heterozygosity based on molecular genetic studies, though this may not be significantly higher than Santa Cruz (42% H). Santa Rosa mtDNA variation and within island APD is amongst the highest observed for all islands. Santa Cruz, however, exhibits the highest allelic diversity and is therefore rated VERY HIGH (Wayne et al. 1991).

DEMOGRAPHY

Demographic comparisons of populations are difficult given the available data. A short history in captivity has provided little data for generating population vital rates. At this time, there is little evidence that populations exhibit inherent differences in vital rates. Comparisons between islands assume equal vital rates across islands under similar husbandry conditions. Demographic projections therefore focus on population-specific age structures and the short-term impacts of age-structure on population persistence and production. Age-structure may be corrected through management over time (especially for Cruz and Catalina through selective capture) so demographic considerations may be more significant to short-term (<20 years) rather than long-term program goals.

Population modeling of current Santa Cruz, Santa Rosa, and San Miguel captive populations was conducted to determine ratings. Ratings for Santa Catalina were deduced assuming collection of an ideal captive population. Detailed demographic model results are presented in TAR 3.6.1.

Probability of captive population survival under fixed harvest schedule: Populations undergoing regimented harvest strategies may be prone to over-harvest and subsequent extinction. Santa Rosa scored highest in this criterion because the captive population has the highest probability of survival in modeled strict harvest scenarios.

Release start year under variable harvest: Variable harvest strategies in which only captive population surplus is harvested results in minimal extinction risk. Harvests only occur after completion of growth to capacity. Santa Rosa and Santa Cruz scored highest in this criterion; time to capacity was lowest in these populations due to relative stability of current age structure.

Release availability under variable harvest: The average number of specimens exceeding population capacity (and thus available for release) per year was calculated over a twenty five year program. Average availability for was greatest for the Santa Cruz and Santa Rosa.

WILD POPULATION STATUS

Considerations regarding current wild population status include long-term factors such as current wild population size and island carrying capacity and short-term factors such as current survivorship of released animals and grazer/predator density. Islands having greater carrying capacities are more likely to support successful reintroduced populations. Islands with smaller carrying capacities may be in greater need of long-term supplementation and have a lower likelihood of post-release success. VERY HIGH indicates wild populations considered most likely to succeed post-release under current island conditions.

DISEASE

Ratings in the disease category relied heavily on the previous analysis of disease risks. Diseases considered are ones known or suspected to cause morbidity or mortality in foxes or other canids. Categories are based on known presence of parasites or prevalence of antibodies (indicating exposure to and possibly protection from infection) and VERY HIGH indicates populations unlikely to spread disease or obtain disease on the mainland. More detailed analyses will need to await completion of necropsies on archived foxes and statistical analyses to assess impact of specific diseases on each island. The impact of captivity on diseases in island foxes is still being investigated. Santa Catalina is rated highest in this criterion having few diseases posing a mainland threat and having previous exposure/immune response to mainland diseases.

Susceptibility to mainland diseases: Potential to acquire lethal strains of canine distemper was prioritized more than potential to acquire canine adenovirus or canine parvovirus, due to no known mortalities (to date) from adenovirus or parvovirus in island foxes. Risk of susceptibility to viral diseases and *Toxoplasma* was based on evidence of survival of subspecies after natural exposure (measured through antibody prevalences for each subspecies). Populations with low antibody prevalence were considered vulnerable.

Risk of spreading diseases to the mainland: Diseases of concern that were prioritized in determining risk were *Spirocerca* and *Angiostrongylus* on the Northern islands (because these parasites are either unique to the Channel Islands or rare on the mainland, the intermediate hosts are not known, and the efficacy of treatment is not known) and *Otodectes* on Santa Catalina (because this earmite has caused more serious disease in the Catalina population than has *Otodectes* infections on other islands, although this increased pathogenicity may be due to fox subspecies susceptibility).

Priority for research: The Santa Catalina subspecies was given high priority because of the seemingly greater susceptibility to lethal forms of canine distemper and more severe ear infections and cancers from *Otodectes* infestations. The size of the Santa Cruz population would be beneficial for any research projects, such as vaccine safety and efficacy that require large numbers of animals.

NEED FOR IMMEDIATE RESCUE

The need for immediate rescue is based on the sum of current captive and wild population sizes. VERY HIGH indicates populations considered to be in greatest endangerment at the current time.

Table 1. Rank within categories (VERY HIGH, HIGH, MODERATE, LOW, VERY LOW where VERY HIGH indicates the best choice for mainland) – categories are UNWEIGHTED.

	Santa Cruz	Santa Rosa	San Miguel	Santa Catalina
Genetics				
Gene Diversity @ 25yrs	VERY HIGH	LOW	VERY LOW	HIGH
Suitability for stocking other islands from phylogeny	HIGH	LOW	VERY LOW	VERY LOW
Suitability for stocking other islands from molecular heterozygosity	VERY HIGH	HIGH	LOW	VERY LOW
Demography				
P(Survival) under strict harvest	HIGH	VERY HIGH	LOW	HIGH
Release start year under variable harvest	VERY HIGH	VERY HIGH	LOW	HIGH
Release availability under variable harvest	VERY HIGH	VERY HIGH	LOW	HIGH
Wild status				
Current population size	LOW	VERY LOW	VERY LOW	MODERATE
Island carrying capacity	HIGH	HIGH	LOW	HIGH
Current post-release survival	LOW	LOW	HIGH	HIGH

Absence of grazers/eagles	VERY LOW	LOW	VERY HIGH	HIGH
Disease				
Safe to move due to low susceptibility to mainland diseases	MODERATE	LOW	LOW	MODERATE
Safe to move due to low potential to spread disease to mainland	MODERATE	MODERATE	LOW	HIGH
Best research potential	HIGH (robust pop for vaccine trial)	LOW (low availability of individuals)	LOW (low availability of individuals)	HIGH (investigate high disease susceptibility)
Immediate rescue need	MODERATE	VERY HIGH	VERY HIGH	VERY LOW

CONCLUSIONS

The key to choosing a subspecies for mainland management lays in first determining mainland management goals. Given clarification of goals, the summary table below (Table 2), indicates the most appropriate subspecies for meeting those purposes.

Table 2. SUMMARY TABLE

Category	Presumed Goal	Recommended Mainland Choice
Genetics	Maximum gene diversity retention and maximum flexibility for restocking other islands if needed	Santa Cruz
Demography	Maximum short term production and minimum extinction risk	Santa Rosa/ Santa Cruz
Wild Pop'n. Status	Likelihood of successful reintroduction based on current island conditions	Santa Catalina
Disease	Least likely to contract mainland diseases and spread island diseases on mainland. Best research population due to possible increased susceptibility to disease.	Santa Catalina
Immediate rescue need	Provide "safe-harbor" for most endangered taxa	San Miguel/ Santa Rosa